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ABSTRACT

In 1963, the Institute began a program of research and development in computer-assisted instruction (CAI). Their efforts have been funded at various times by the Carnegie Corporation of New York, The National Science Foundation and the United States Office of Education. Starting with a medium-sized computer and six student stations, the Institute has expanded to a PDP-10 computer and teletypes in elementary schools in several states, connected by telephone lines to the Institute. Drill-and-Practice programs in mathematics and reading were developed and tested. Tutorial programs in mathematics and reading were also developed. Tutorial logic and algebra programs along with a tutorial Russian language program have been added to the systems' capability. A dial-a-drill program was instituted which allows students in their homes to be given oral exercises in elementary mathematics. The report covers the development of the programs and supporting equipment chronologically and provides tables of statistical information concerning the programs, students, and participating schools. (JY)

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October, 1968

BRIEF HISTORY OF COMPUTER-ASSISTED INSTRUCTION

at the

INSTITUTE FOR MATHEMATICAL STUDIES IN THE SOCIAL SCIENCES

Stanford University

In January 1963, the Institute began a program of research and development in computer-assisted instruction. The initial effort was funded by the Carnegie Corporation of New York for a period of five years. Additional funds were provided after January, 1963, by the National Science Foundation. These grants led to the construction of a computer-based laboratory for learning and teaching on the Stanford campus. The laboratory itself has been in operation since December 1963, and the Institute has conducted a program of instruction in schools not only in California, but in other parts of the country as well.

The Institute's program in computer-assisted instruction is under the direction of Patrick Suppes and Richard C. Atkinson, who are both members of the Stanford faculty. In its initial inception, John McCarthy of the Department of Computer Science at Stanford played an important role in the design and activation of the Institute's computer facilities. The various research projects, briefly described below, have been supported not only by the Carnegie Corporation of New York, but also by the National Science Foundation and the U. S. Office of Education.

The initial instructional system in the Institute consisted of a medium-sized computer and six student stations placed within 100 feet of the computer. Each student booth contained two visual display devices. The first was a random-access optical-display device developed for the laboratory by IBM Corporation that presented microfilmed source material on a 10-inch by 13-inch ground-glass screen. It was possible to encode the equivalent of a 512-page book (8-1/2-inch by 11-inch standard page) on microfilm and any page or one-eighth of a page could be displayed randomly within 1 second. The student responded to the display by using a light pen on the face of the screen itself. As the pen was touched to the screen, the coordinates of that position were sent to the computer for comparison with any predesignated areas of the screen. The accuracy of the light pen permitted identification of a 1/4-inch square on the screen. This device, which is the predecessor of the IBM-1500 system mentioned below, has been phased out and is no longer in the Institute.

The second display device, which is still in use, was developed for the Institute by the Philco Corporation. It is a cathode-ray tube, commonly called a "scope." It can display points of light in an area 10 inches high by 10 inches wide with 1,024 possible positions on both the horizontal and vertical axes. In addition to individual points, there are 120 prearranged characters which may be displayed in five different sizes. It is also possible to display vectors by simply identifying the end points. A typewriter keyboard is attached to the scope and may be used to send information from the student to the computer.

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An audio system designed by Westinghouse Corporation can play prerecorded messages to the user through individual speakers in each student booth. The messages are recorded on magnetic tape 6 inches wide; two tape transports may be assigned to each of the six student stations. Each transport has a capacity of about 17 minutes, which can be used in any combination (e.g., from one message 17 minutes in length to 1,020 messages of 1 second each). The random-access time to any stored message is approximately 1 second. For a number of technical reasons, this equipment is no longer in operation in the laboratory.

Until June, 1968, the central computer was a PDP-1 designed by Digital Equipment Corporation. It has a 32,000 word core and a 4,000 word core, which can be interchanged within the 32 bands of a magnetic drum on files stored on two IBM-1301 disks. (The two IBM-1301 disks were replaced by two IBM-2314 disks in the fall of 1968, and a PDP-10 has become the main computer, although the PDP-1 is still in operation.)

The first operational instructional program available in any form at all was a program in elementary mathematical logic. This program was first demonstrated on December 12, 1963, and two lessons consisting of 23 problems were run with four sixth-grade students on December 20, 1963. An additional two fifth graders were run for demonstration purposes on January 7, 1964. An occasional demonstration was given every month or so during the spring. More importantly, some 20 lessons giving a fairly detailed introduction to sentential logic were written and programmed during the spring. In the summer of 1964, these lessons, which were presented on the scopes, were run with two fifth-grade boys. One boy had 32 sessions for a total of more than 15 hours at the terminal, and the second boy had 38 sessions for a total of more than 36 hours at the terminal.

During the spring of 1964, preliminary experiments using first-grade mathematics material were also conducted in the Institute with 29 kindergarten children. Throughout 1964, staff members worked to write and code for the computer CAI programs for first-grade and fourth-grade mathematics and for mathematical logic.

1964-65

During the 1964-65 school year, two groups of six first-grade children were given a preliminary version of the first-grade arithmetic program during the regular school year (September 14 - June 11, 1965). Two kindergarten children were given a revision of the first-grade program in the spring (March 15 - June 25, 1965).

Two very capable second-grade boys worked through a portion of the logic program (March 15 - May 19, 1965) and 26 second-grade children, all very capable, worked through a revision of the logic during the summer of 1965 (July 5 - 30, 1965).

By remote control, 41 fourth-grade children were given daily arithmetic drill-and-practice lessons on a teletype machine in their classroom at Grant School in the Cupertino Union School District (April 19 - June 4, 1965). This installation constituted an important first step in moving terminals from the Stanford campus to elementary schools, with direct connection from the computer to the terminals by telephone lines.

1965-66

During the 1965-66 school year, drill-and-practice teletype programs were conducted in three schools. In September, the arithmetic drill program at Grant School was expanded, with two teletypes for each of grades 4, 5, and 6. On February 2, 1966, two more teletypes were added for third-grade classes. By the end of the year, of the 270 participating students, 62 were third graders, 76 were fourth graders, 70 were fifth graders, and 62 were sixth graders.

On March 1, 1966, one teletype was installed at Ravenswood High School in the Sequoia Union High School District. The machine was used by seven arithmetic classes. About 60 students used the machine on alternate days.

During the spring of 1965, four teletypes were used for drill-and-practice work in spelling at Costano School in Ravenswood City School District. Audio was provided from the Institute's central computer facilities by a second telephone line and earphones.

During 1965-66, work on tutorial programs was continued in both the mathematics and the mathematical logic programs. Two groups of four kindergarten children were given a revised version of the first-grade program during the regular school year (April 11, 1966 - June 10, 1966). Two groups of first-grade children were given a revised version of the second-grade program (April 11, 1966 - June 10, 1966). Drill-and-practice lessons in symbolic logic were given to 30 sixth-grade students one day each week from May 5, 1966 through June 9, 1966. A group of 7 fourth-grade students were given the same lessons in logic for a period of four weeks, one day each week (May 19, 1966 - June 9, 1966).

During the summer of 1966, writing groups worked on both drill-and-practice and tutorial materials for CAI instruction.

In the summer of 1964, the Institute was granted a contract by the United States Office of Education to establish a computer-based instructional laboratory at a public elementary school for the purpose of investigating computer-assisted instruction over an extended period of time.

The Stanford-Brentwood Computer-Assisted Instruction Laboratory was housed in a specially built laboratory at Brentwood Elementary School (Ravenswood City School District) in East Palo Alto, California. The Laboratory was equipped with an IBM-1500 Instructional System operated by an IBM-1800 computer. (Use of this equipment was terminated on July 1, 1968.)

1966-67

The Brentwood Laboratory was used to teach mathematics and reading to elementary-school children and to collect data on their learning behavior. Over 100 children participated in the project for the 1966-67 school year, including all the first-grade students at Brentwood. Half of the students had daily computer-assisted instruction in mathematics, and the other half had daily sessions in reading.

In addition, the drill-and-practice program was expanded during 1966-67. Grant School in the Cupertino School District continued and Walter Hays School in the Palo Alto Unified School District began drill-and-practice programs in arithmetic for third through sixth grades. A first- and second-grade arithmetic drill-and-practice program was carried on at Oak Knoll School in the Menlo Park City School District. At Clifford School in the Redwood City School District there was an arithmetic program and at Ravenswood High School there was a ninth-grade program for general mathematics students. At Costano the work in spelling fundamentals for fifth and sixth graders continued. In March two teletypes were started for second- and sixth-grade arithmetic drill at Breckenridge, the Morehead State University Laboratory School in Morehead, Kentucky. One of the teletypes was moved to an elementary school in Elliotville, Kentucky for the last six weeks of school. By the end of the term, grades one through six were participating.

Grant School began operation in September, with 288 students on eight teletypes; Ravenswood, on October 29, with 68 students on two teletypes; Walter Hays, on November 28, with 252 students on eight teletypes; Oak Knoll, on December 8, with 107 students on four teletypes; and Clifford, on January 3, with 162 students on four teletypes. During the year classes were added at all schools, so that the starting number of 877 students increased to slightly over 1,500 students at the end of the year.

In addition, 31 students at Walter Hays participated in a teletype program on symbolic logic and modern algebra. Also, the Institute's PDP-1 computer system was used for several projects in the summer of 1967. On June 15, a summer session began in elementary schools in Kentucky, in which 28 teletypes were used for arithmetic drills. Teletypes were used for grades one through six. Students from one Morehead State University Upward Bound program participated, and teletypes were also in operation at Breckenridge and Rowan County High School. (The terminals in Kentucky were connected by telephone lines to the Institute's computer at Stanford.) On June 29, Roosevelt Junior High School in the San Jose City School District began with two teletypes being used for drills in the summer-school session.

1967-68

Seventy-three students continued in the 1967-68 tutorial mathematics program at the Brentwood Laboratory. A new mathematics curriculum was initiated for the second grade.

The drill-and-practice mathematics program expanded again during 1967-68. From the end of January, 1968, to the end of May, 1968, the enrollment jumped from 2,387 to 3,823 for schools in California, Iowa, Kentucky, and Mississippi (see Table 1). A list of the schools involved in the program is given in Table 2. From April to July, 1968, three workshops for approximately 150 teachers and administrators were held at Morehead State University.

The 640 students enrolled in the drill-and-practice program in the Job Corps Center in Clinton, Iowa were high-school-age girls and older. These girls concurrently attempted to learn a trade and to earn a high-school diploma. The majority of these students worked at the fourth-grade level.

TABLE 1

Stanford 1967-68 Programs in Computer-Assisted Instruction

(The number of students shown is for May 15, 1968)

Program	Number of students Jan.	May	Terminals
Drill-and-practice Mathematics, Grades 1-8			
California	985	1,441	TTY
Kentucky	810	1,632	TTY
Mississippi	592	640	TTY
Tutorial Mathematics, Grade 2	76	76	CRT + Audio + Film
Tutorial Reading, Grade 1	73	73	CRT + Audio + Film
Tutorial Logic and Algebra, Grades 5-8	195	195	TTY
Tutorial Russian, University level	30	30	TTY + Audio (Cyrillic keyboard)
Dial-a-Drill	15	15	Telephone

TABLE 2

Schools Participating in the Drill-and-practice and Logic and Algebra Programs
1967-68

School	Drill-and-practice	Logic and Algebra
Grant School, Los Altos, Calif.	x	x
Garden Oaks Jr. High, East Palo Alto, Calif.	x	
Peter Burnett Jr. High, San Jose, Calif.	x	
Walter Hays School, Palo Alto, Calif.	x	x
Oak Knoll School, Menlo Park, Calif.	x	x
Clifford School, Redwood City, Calif.	x	x
Fremont Hills School, Los Altos Hills, Calif.	x	x
Eva Gordon Attendance Center, Magnolia, Mississippi	x	
Alpha Center, McComb, Mississippi	x	
Kennedy Elementary School, McComb, Mississippi	x	
Universal School, McComb, Mississippi	x	x
Westbrook Elementary School, McComb, Mississippi	x	
Taggart School, McComb, Mississippi	x	
Netterville School, McComb, Mississippi	x	
Otken School, McComb, Mississippi	x	x
Hughes School, McComb, Mississippi	x	
Summit Elementary School, McComb, Mississippi	x	
Lillie Mae Bryant Attendance Center, Meadville, Mississippi	x	
Franklin Attendance Center, Meadville, Mississippi	x	
Job Corps, Clinton, Iowa	x	
Breckinridge School, Morehead, Kentucky	x	
Elliotville Grade School, Elliotville, Kentucky	x	
Morehead Grade School, Morehead, Kentucky	x	
Paintsville Grade School, Paintsville, Kentucky	x	
Upper Tygart School, Olive Hill, Kentucky	x	
W. R. Castle Memorial School, Wittensville, Kentucky	x	
Pikeville City School, Pikeville, Kentucky	x	
Flat Gap School, Flat Gap, Johnson County, Kentucky	x	
Louisa Elementary School, Louisa, Kentucky	x	
Sandy Hook Elementary School, Sandy Hook, Kentucky	x	

The logic and algebra tutorial program increased to 195 students in seven schools in California and Mississippi (see Table 2). This is the only program aimed mainly at very bright students and is offered as a supplement or enrichment to the regular mathematics program.

Fifteen students in grades 2 through 6 participated in the dial-a-drill program. Students in their homes were given oral exercises in elementary mathematics by means of computer-generated speech and responded by using a touch-tone dialing pad, which is now standard equipment on telephones in many parts of the United States. This is the Institute's first operational experience of bringing computer-based curriculum into the homes of students rather than into the schools.

In September, 1967, 30 students at Stanford University enrolled in a course of computer-based Elementary Russian for credit. The control class received regular classroom instruction, attended the language laboratory, and submitted written homework assignments. In the computer-based instruction class, regular classroom instruction was eliminated and work at Model-35 teletypes with Cyrillic keyboard and audiotapes with earphones was substituted. At the end of the first year, the computer-based students performed at a statistically significantly higher level. Perhaps equally as important as the superior performance was a much smaller drop-out rate for the computer-based section than for the regularly taught sections of the course.

In the Russian course the students received instruction at the computer-based terminals for a period of 50 minutes per day, five days a week, throughout the entire academic year.